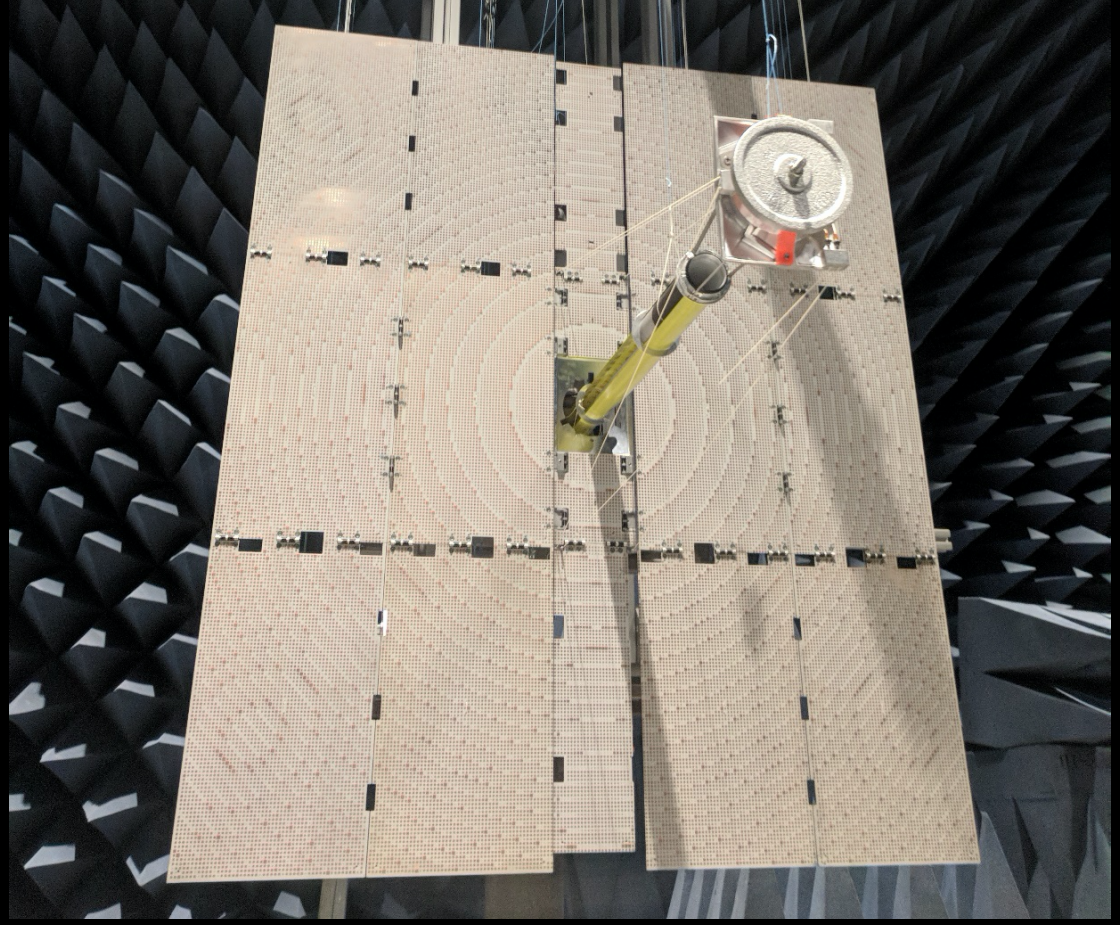

Deployment Mechanisms for High-Packing-Efficiency One-Meter Reflectarray Antenna (OMERA)

Jonathan F. Sauder, Manan Arya, Nacer Chahat, Ellen Thiel, Sean Dunphy, Mengjan Shi, Greg Agnes, Tom Cwik

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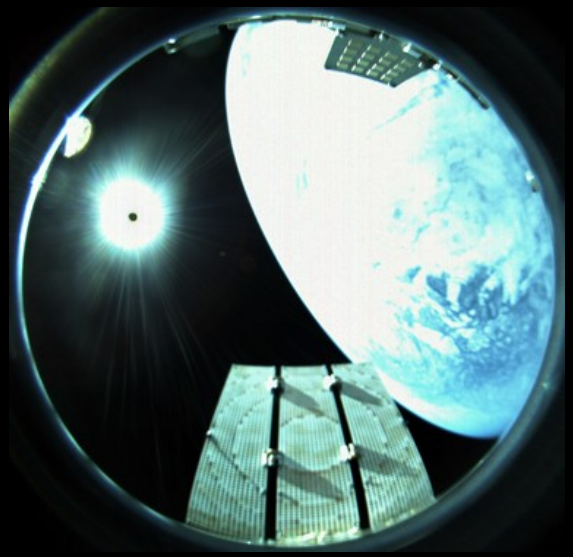
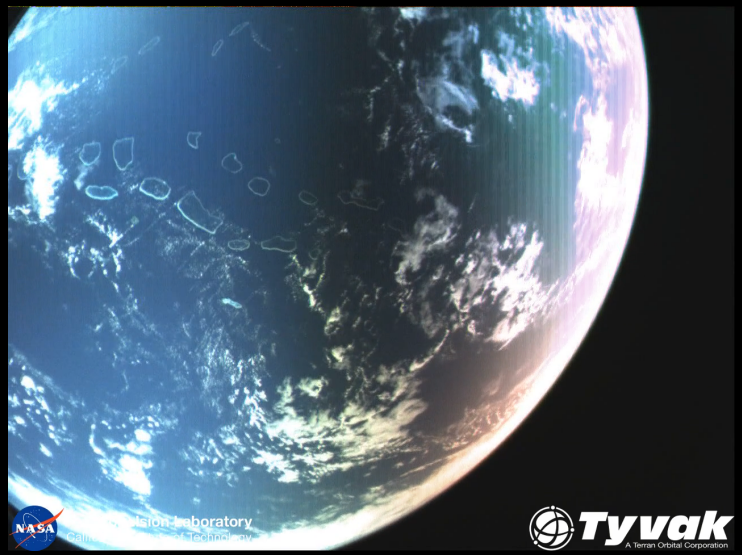
2018 was the year of:

High Gain CubeSat Reflector Deployments



ISARA
Dep. Jan 2018

MarCO
Dep. May 2018



RainCube
Dep. July 2018

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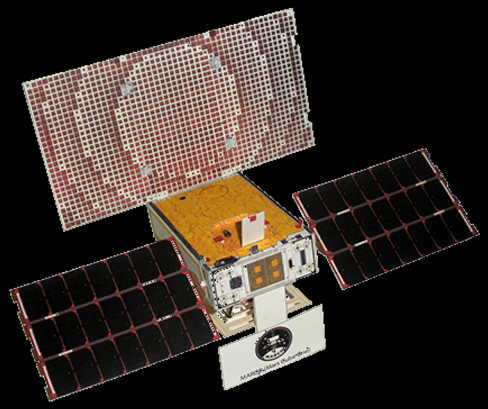
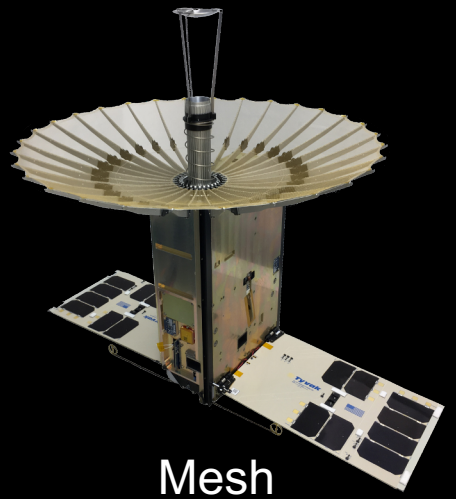
Deployable, High Gain Reflectors for CubeSats

Key Categories: Mesh, Reflectarray, Inflatable and High Strain Composite

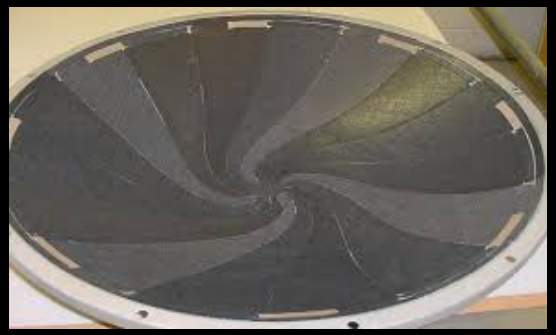


Reflectarray
MarCO



Mesh
RainCube

Inflatable Antenna
Babuscia, et. al.



High Strain Composite
Reynolds, Murphy, Banik

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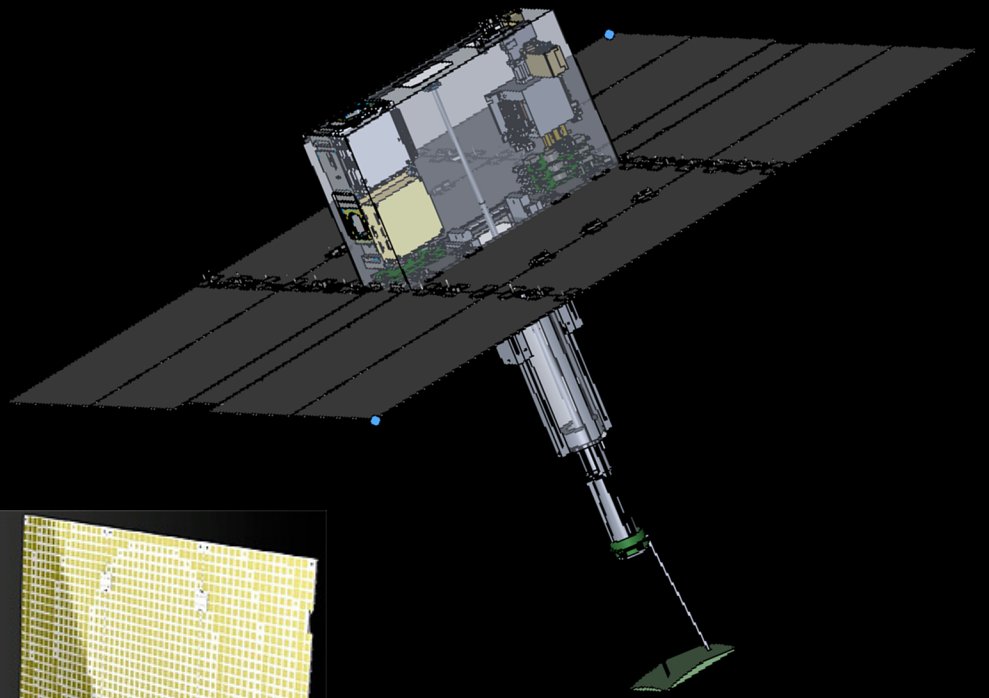
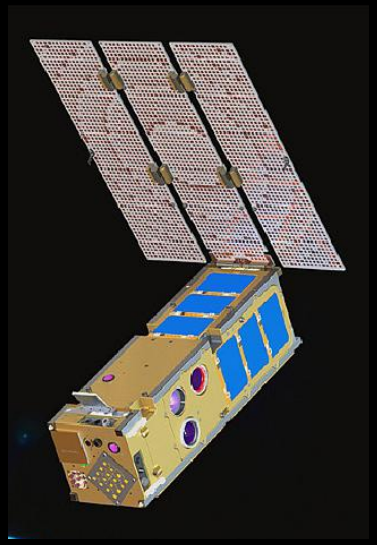
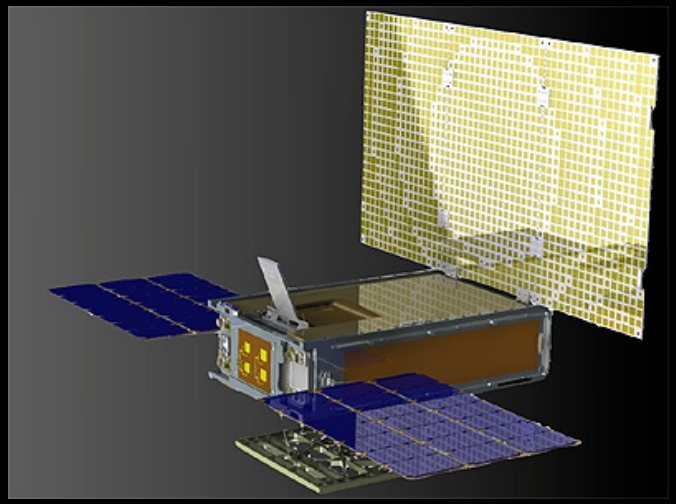
Reflectarrays

ISARA, MarCO, and what's next?







OMERA Requirements: 1x1 Meter in 6U

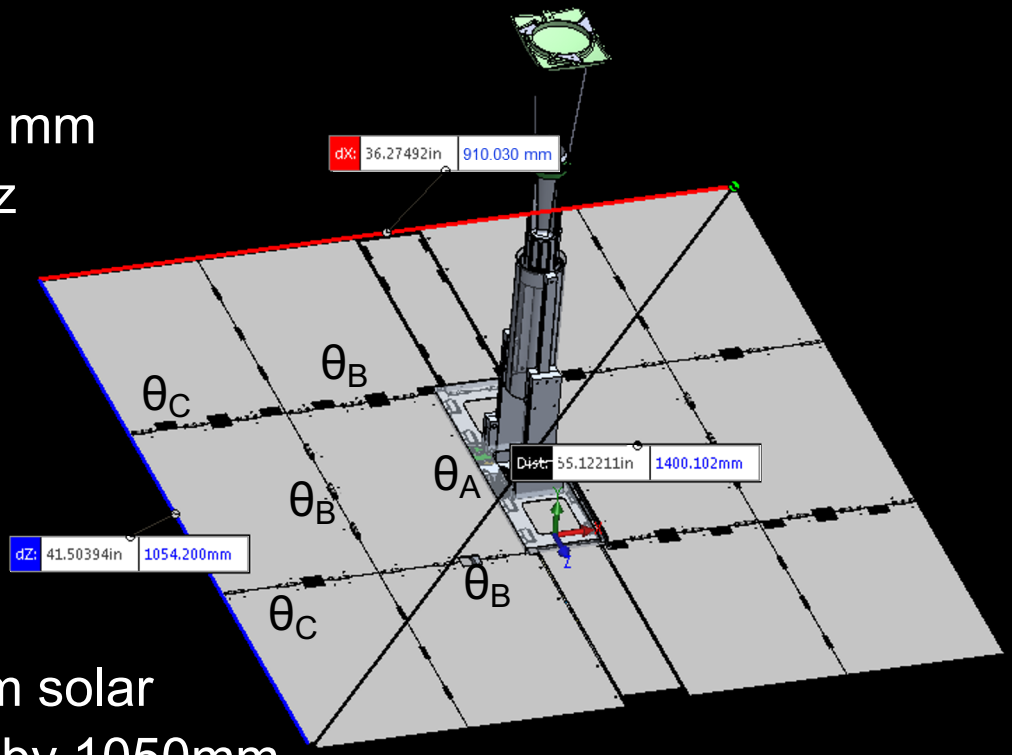
Ka-band (35.75 Ghz) Reflectarray Antenna

Feed Design:

- Absolute deployment accuracy of 0.4 mm in X, Y, and Z, including thermal.
- Consumes less than 2U
- Deploys from 230 mm to 667 mm
- First mode greater than 0.1Hz

Panel Design:

- RMS error of 0.4 mm
- Translates to angles of:
  - $\theta_A = \pm 0.03$
  - $\theta_B = \pm 0.04$
  - $\theta_C = \pm 0.10$
- Deploy from 358mm x 201mm solar panel "bonus space" to 910mm by 1050mm.



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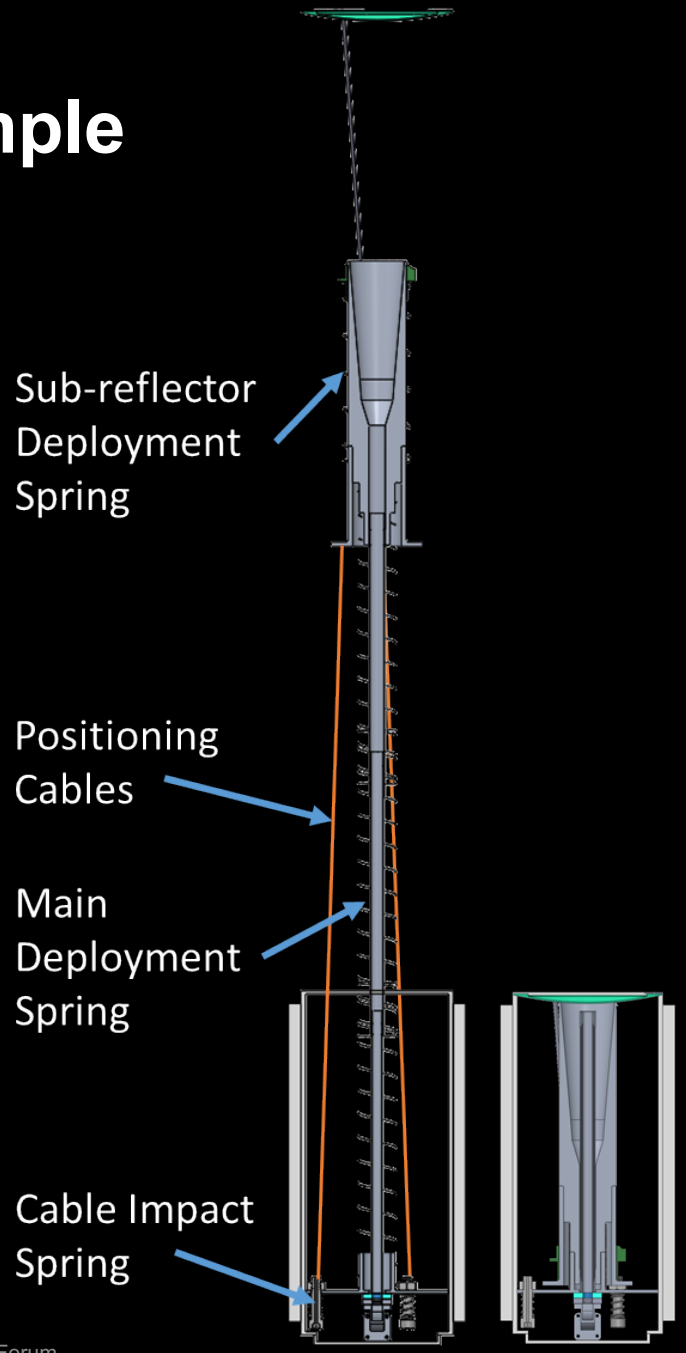
First Feed: Quick, Fast, and Simple

Decouple deployment and position



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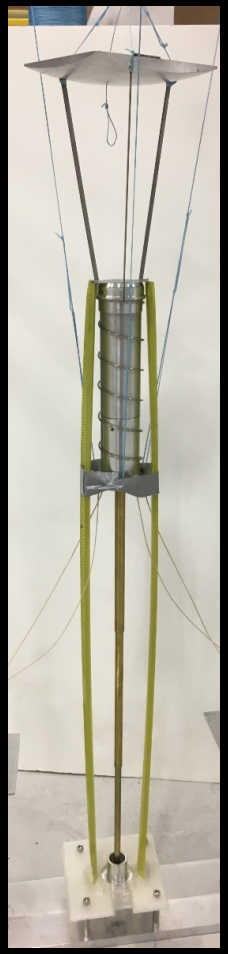
Tape Driven Feed

Early Prototype: Modified Spring Design to Check Tapes



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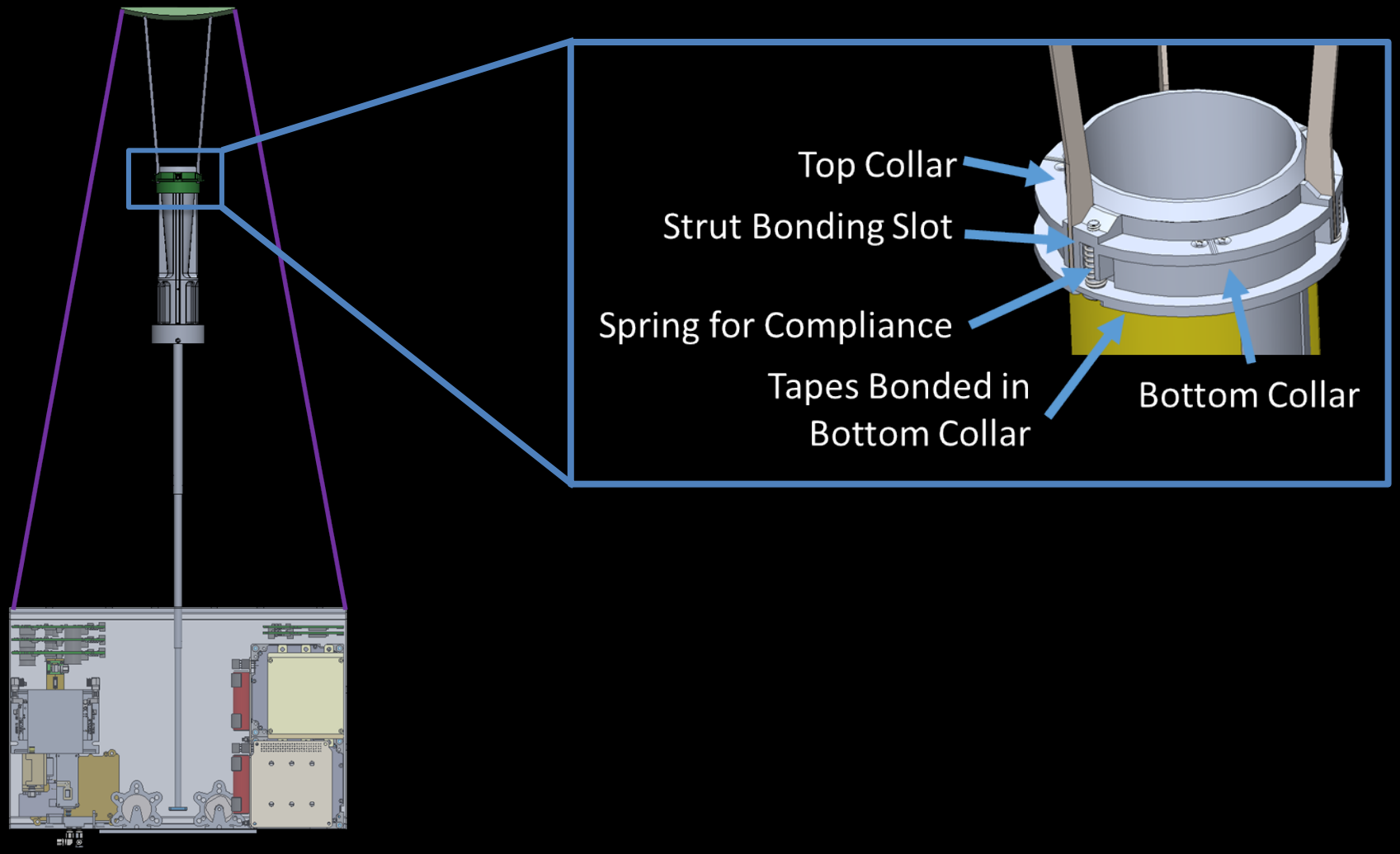
Tape and Feed Connection

Key Component to Separate Deployment from Positioning



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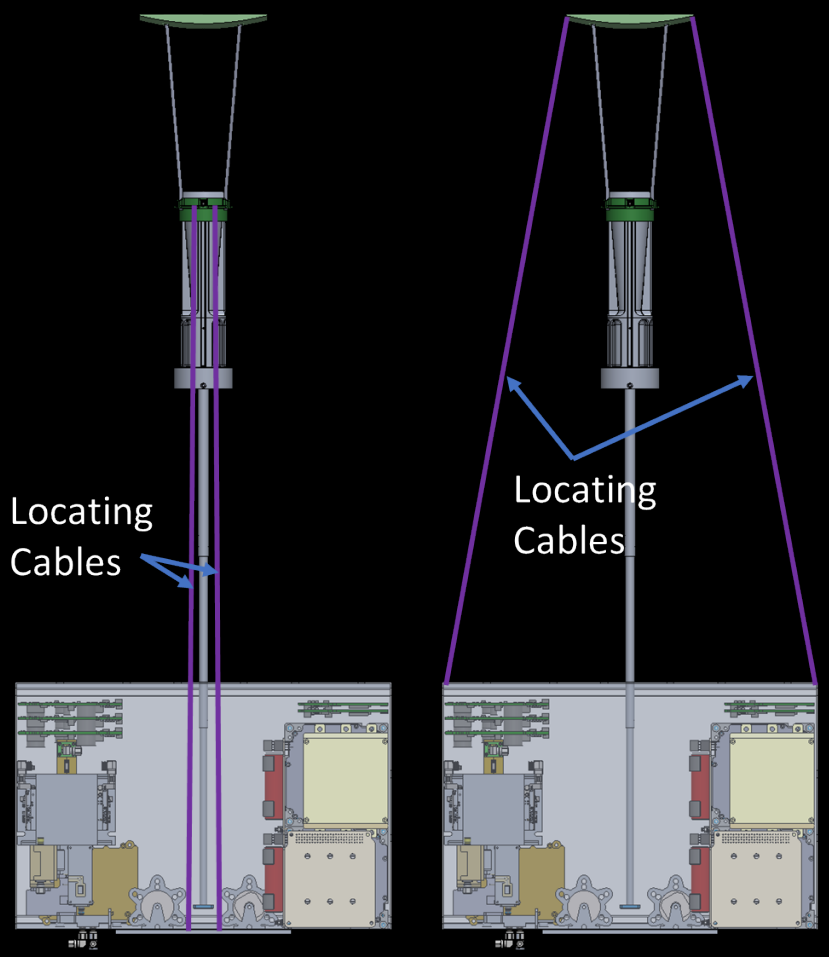
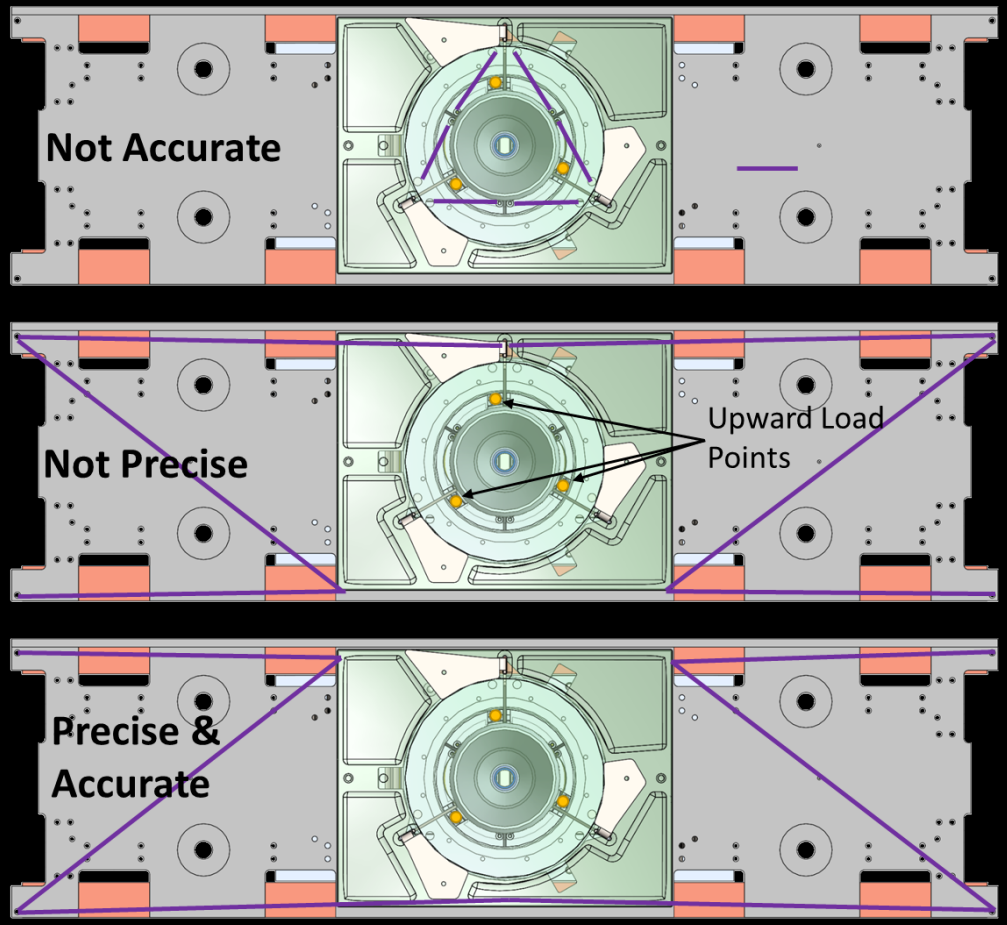
Basic Concept: Cable Hexapod

Quartz Cable Placement is Critical





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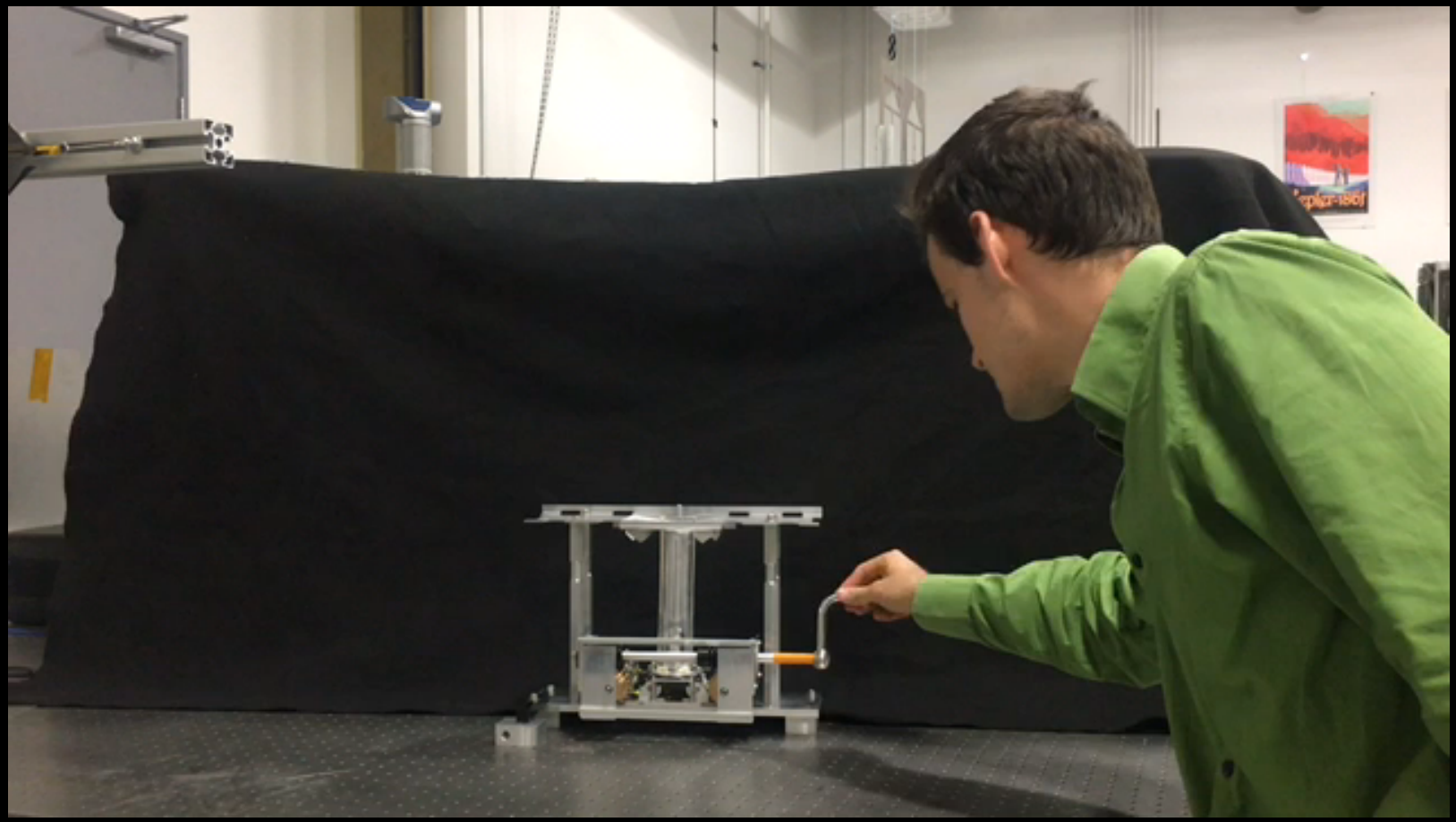
Tape Driven Feed

Hand Crank Deployment



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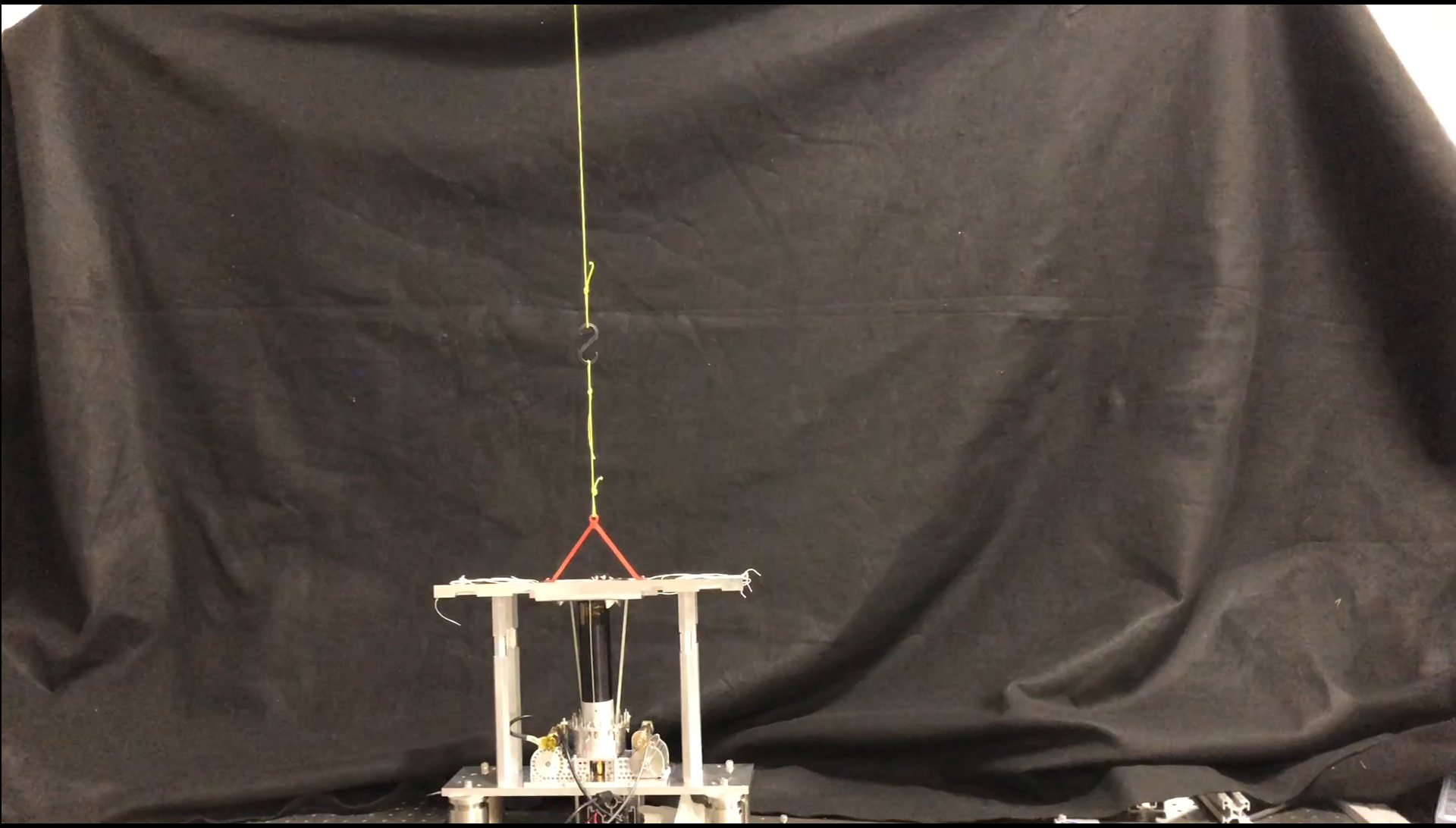
Tape Driven Feed

Motorized Deployment



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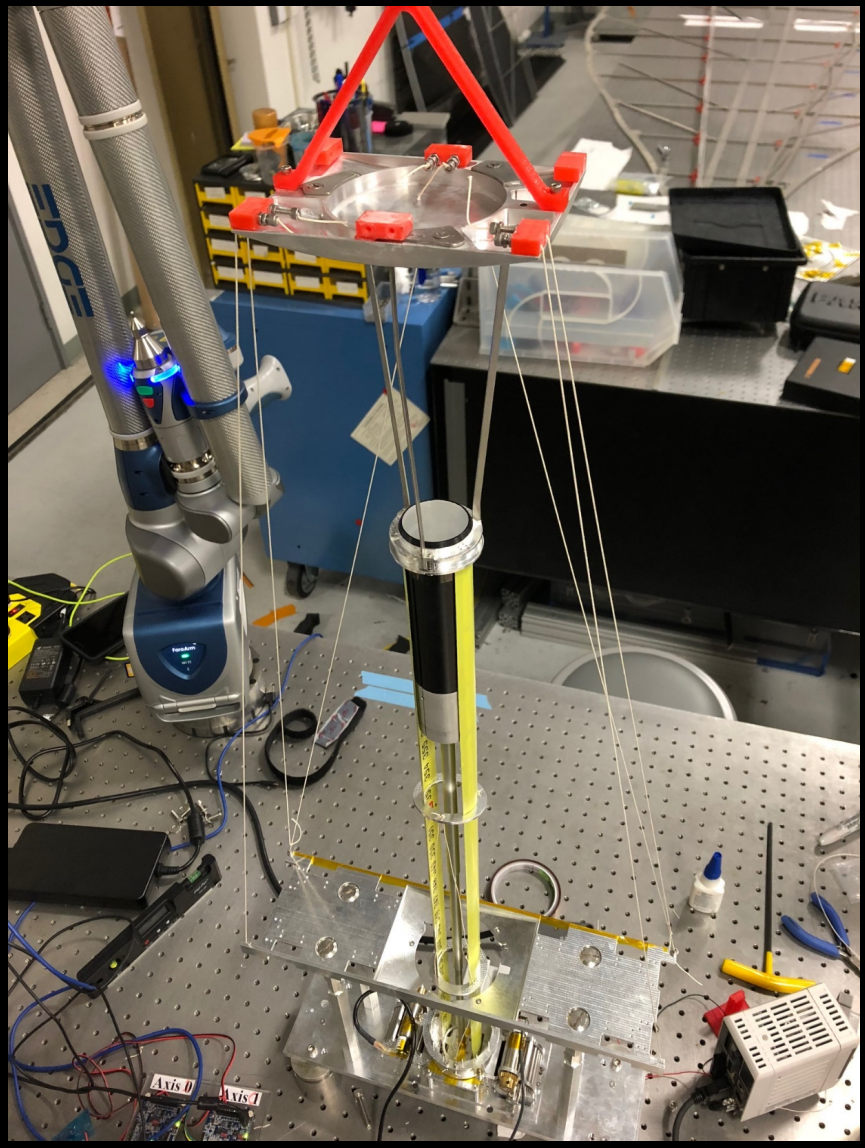
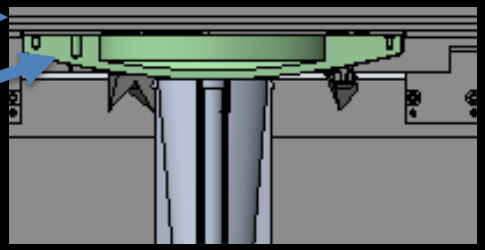
Tape Driven Feed

A Closer Look



Feed Stows
Below Two Panels

Recess
Matches Feed



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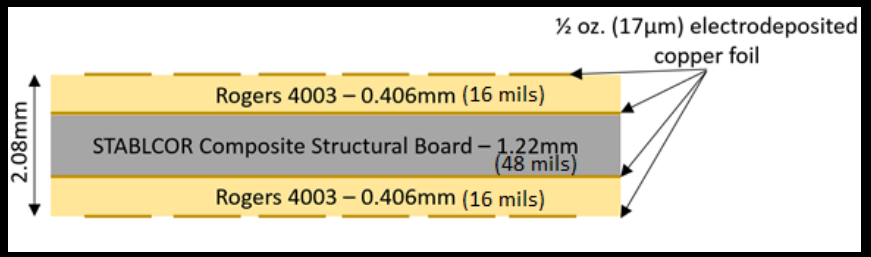
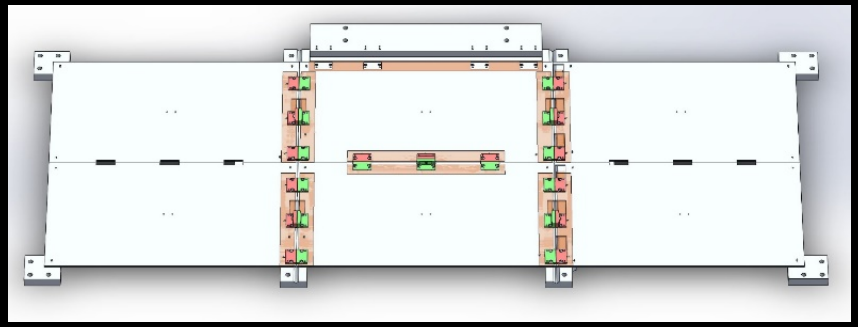
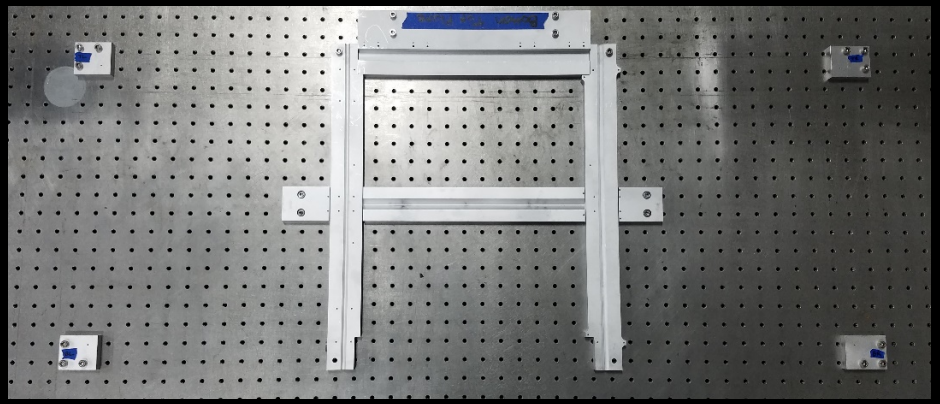
Panel Development

Attaching Panels:

- Panels arrive from vendor
- Panels aligned in bonding fixture
- Hinges are inserted into bonding fixture
- One set of six panels are bonded at a time







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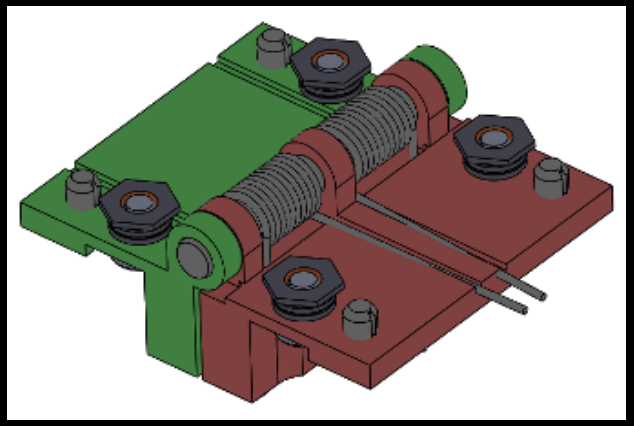
Hinge Development

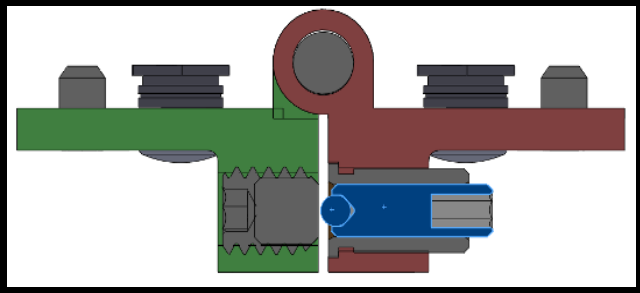
Hinge Mechanism:

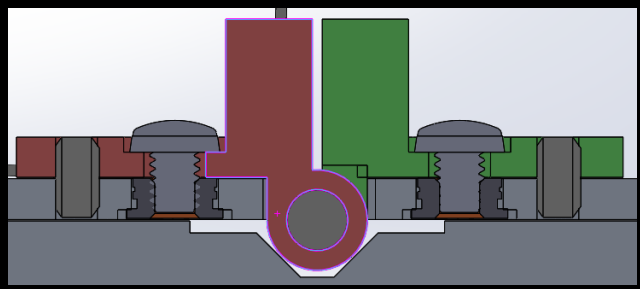
- Right hand/left hand torsion spring deploys hinge while balancing out-of-axis torque.
- Each hinge line (except root), has one positioning hinge with set screw in the middle.
- Ball-tipped fine-thread set screw (200 µm pitch) contacts steel insert

Hinge Attachment Features:

- Interface between panel and hinge body is bonded.
- Located on panel by a set of pinned joints.
- Held flush to panel via screws and inserts







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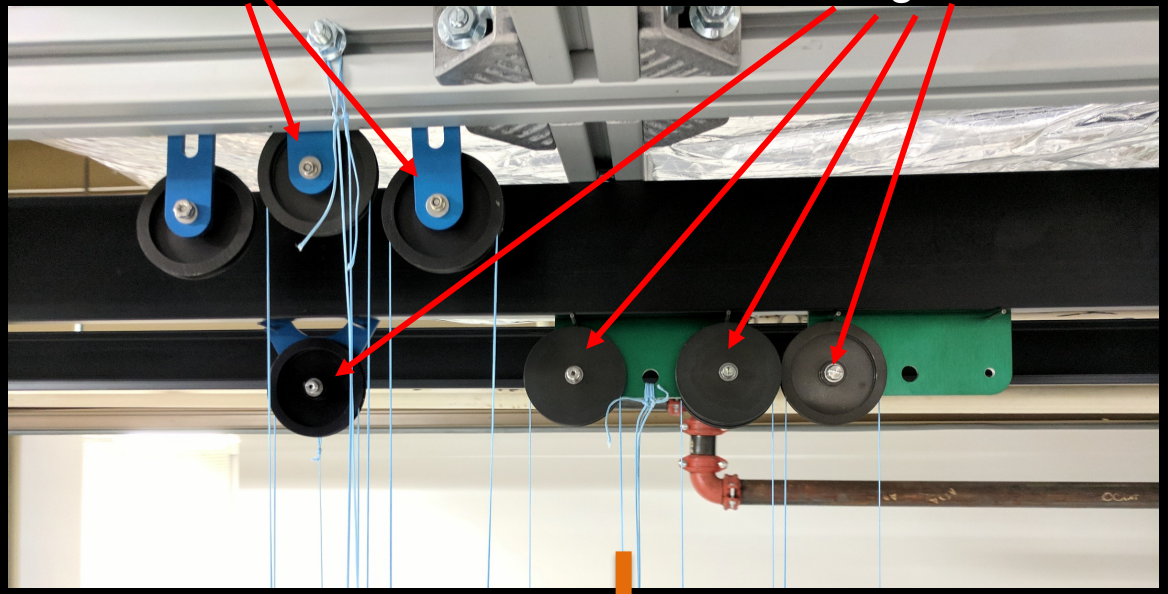
Testbed Panels

Testing Hinge Design and Bonding Process

2 pulleys fixed in position

4 pulleys on 3 carts free to move along a track



Panels are 3.3 meters below offload system

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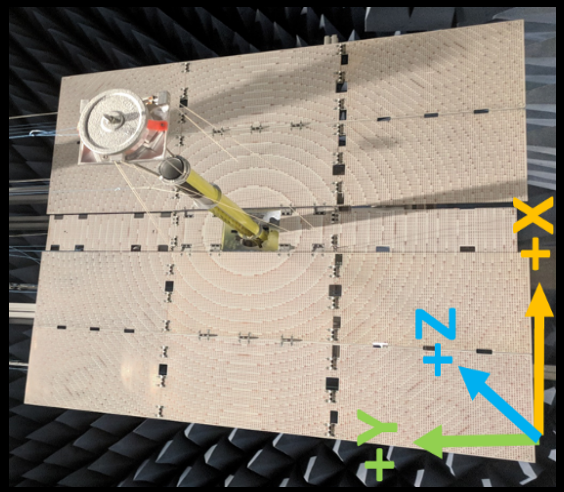
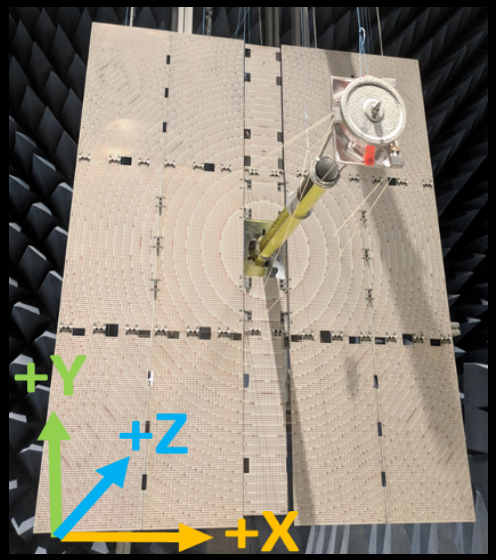
Deployment Repeatability and RF Testing



For Feed Deployment



For Panel Deployment

To Measure Accuracy

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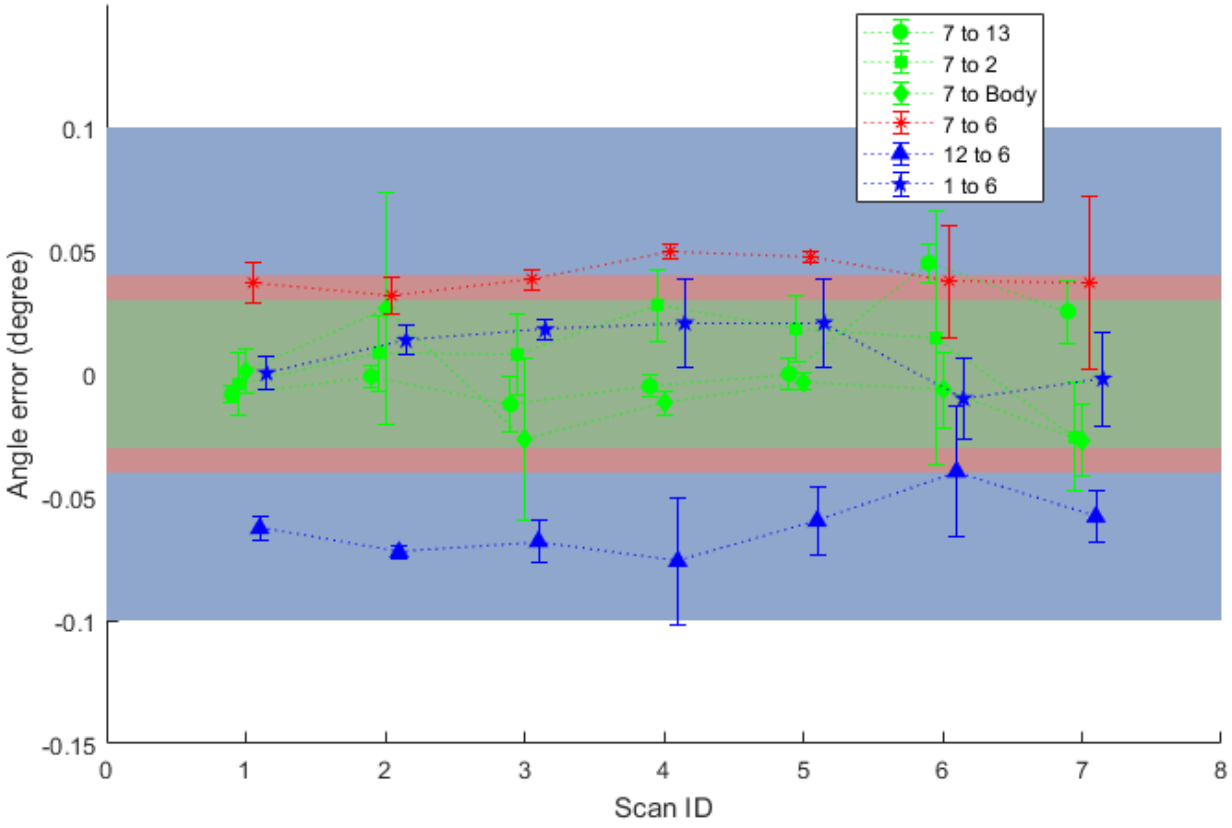
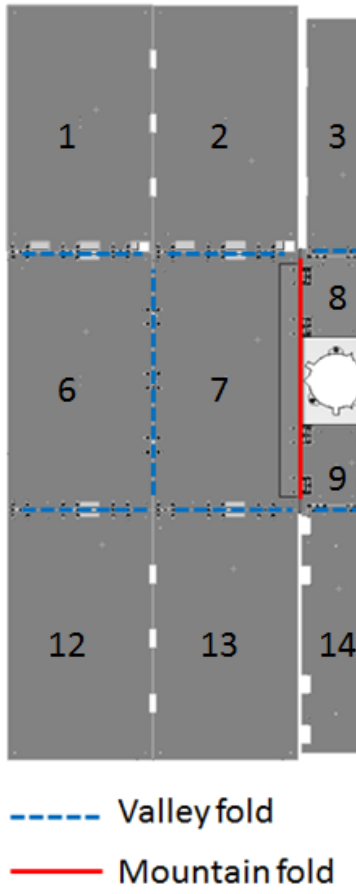
Panel Deployment Repeatability





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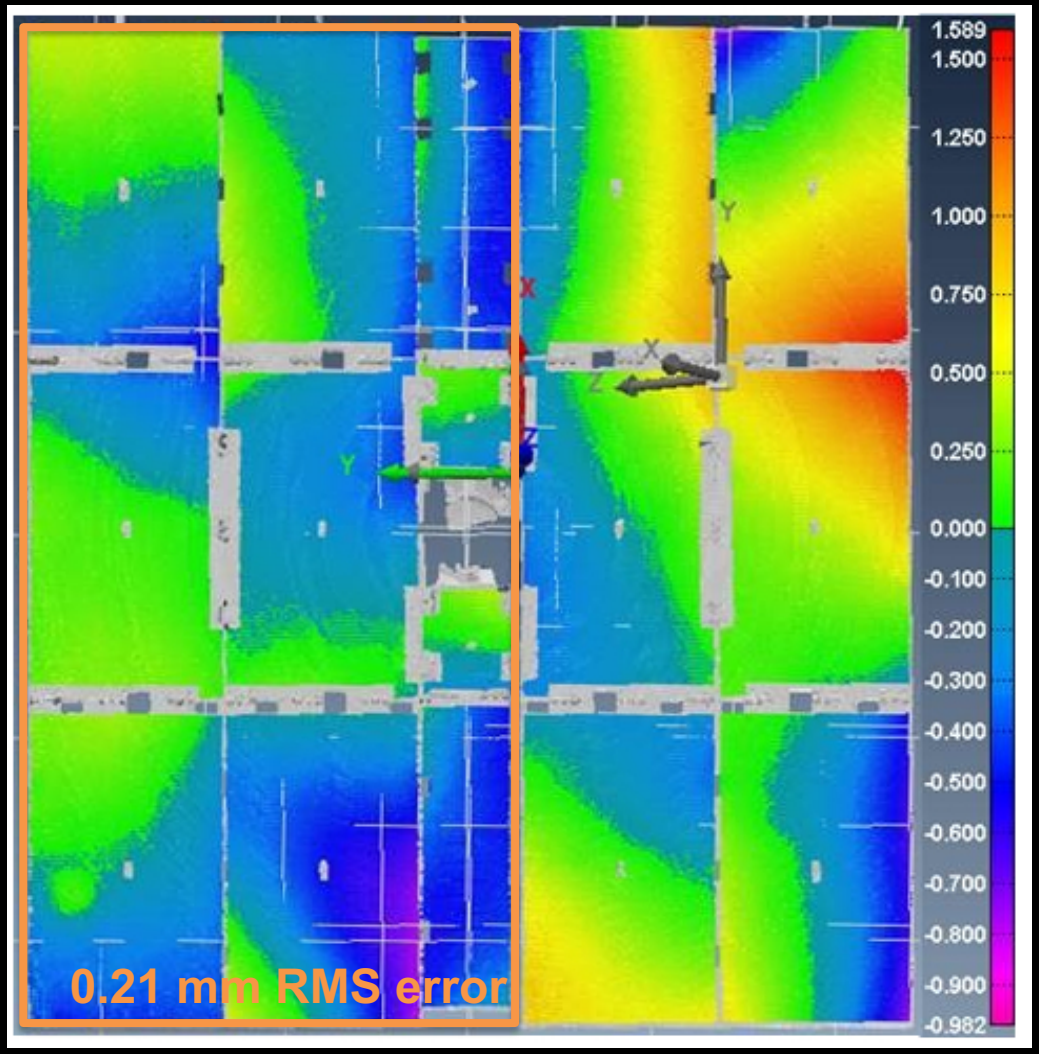
Panel Surface as Test

RMS error of 0.345 mm



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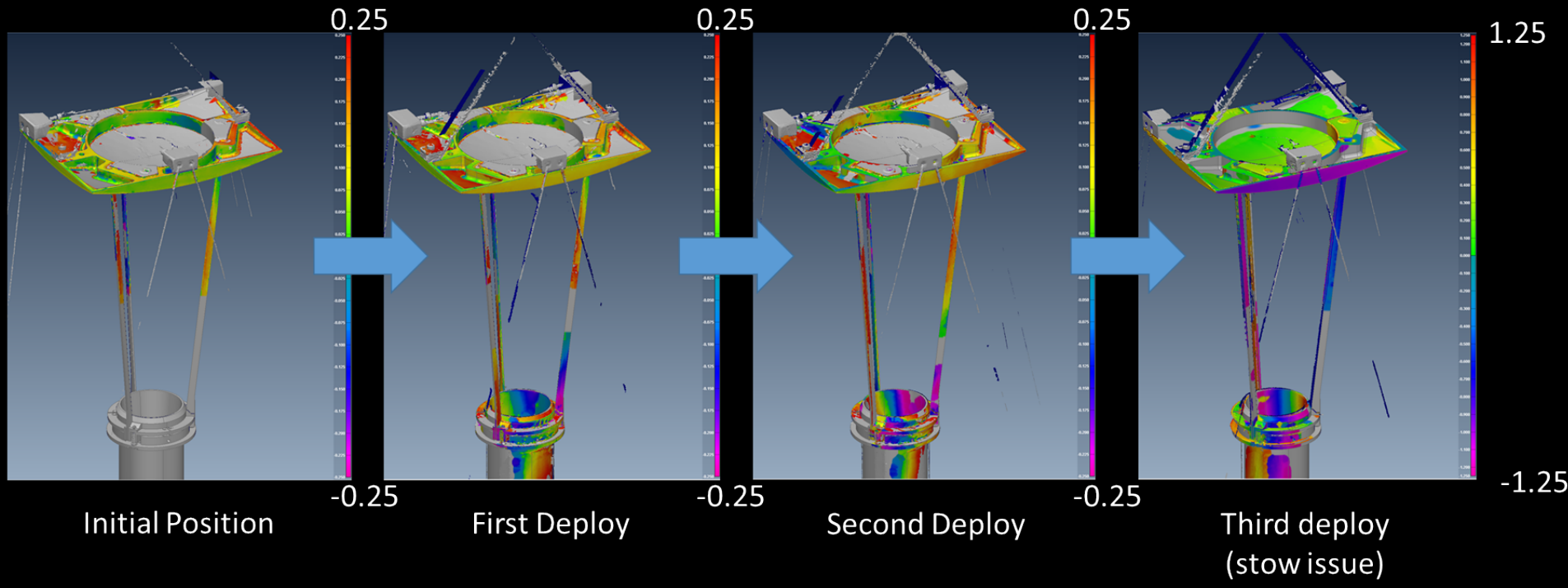
Feed Deployment Repeatability

Repeatability was great until fully secured in last stow



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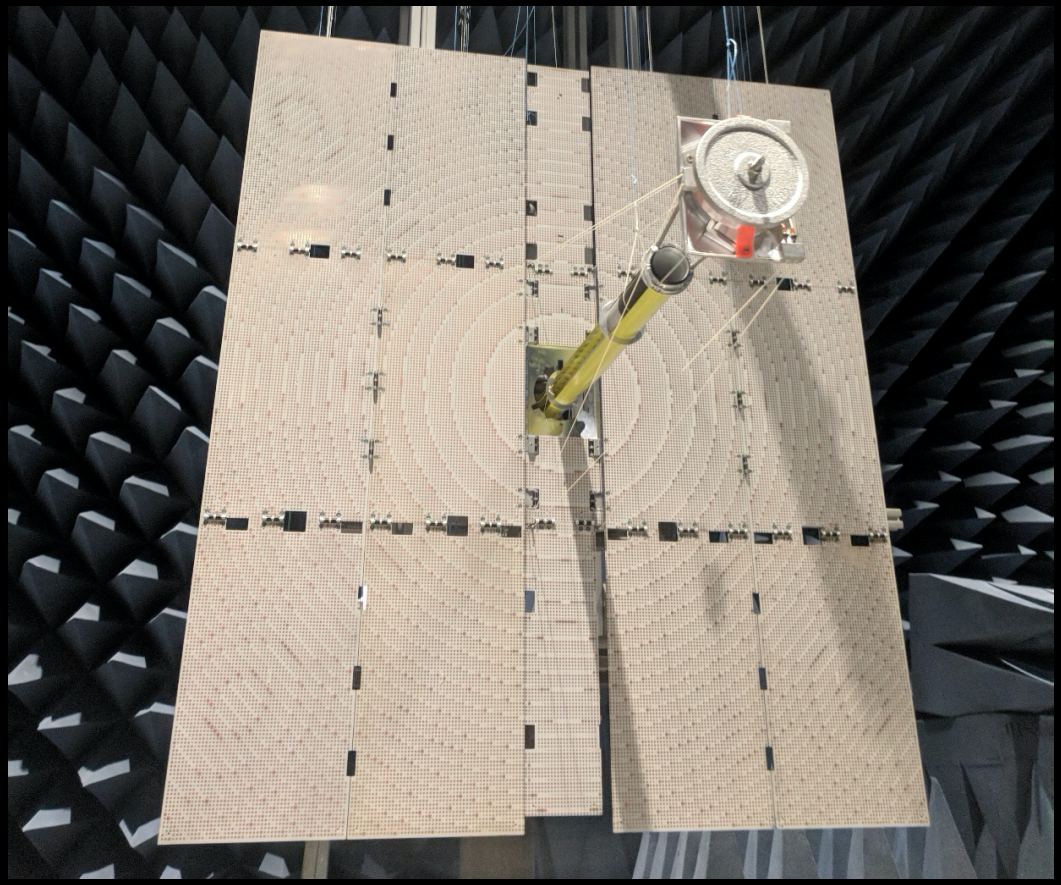
RF Testing

Panels and Feed were deployed by hand in the range



Performance Matched Simulations at 48.0 dBi @ 35.75 Ghz

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Future Steps for Panels

- While 0.345 mm RMS error is within target, target value is 0.2 mm RMS error to account of on orbit disturbances.
- To improve:
  - Work with vendor to develop flatter panels
  - Improve bonding process to accommodate for remaining warp in the panels
  - Manufacture hinges with tighter tolerances to improve precision.
    - Current hinges were built to 0.1 mm tolerance.

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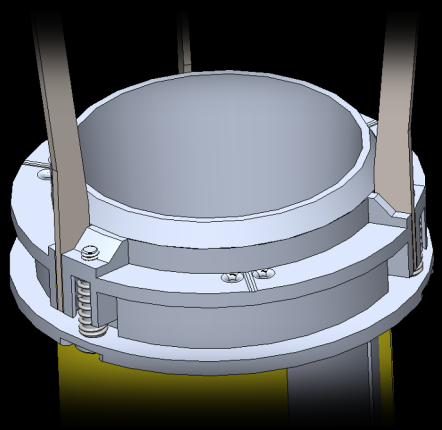
Future Steps for Feed

- Feed had correct repeatability until fully loaded into the stowed position.
- To improve:
  - Redesign the feed collar to enable greater compliance.
  - Add encoders to the tapes to precisely control position of the tapes, not just the motors.
  - Switch from twisted quartz thread to a unidirectional cable.



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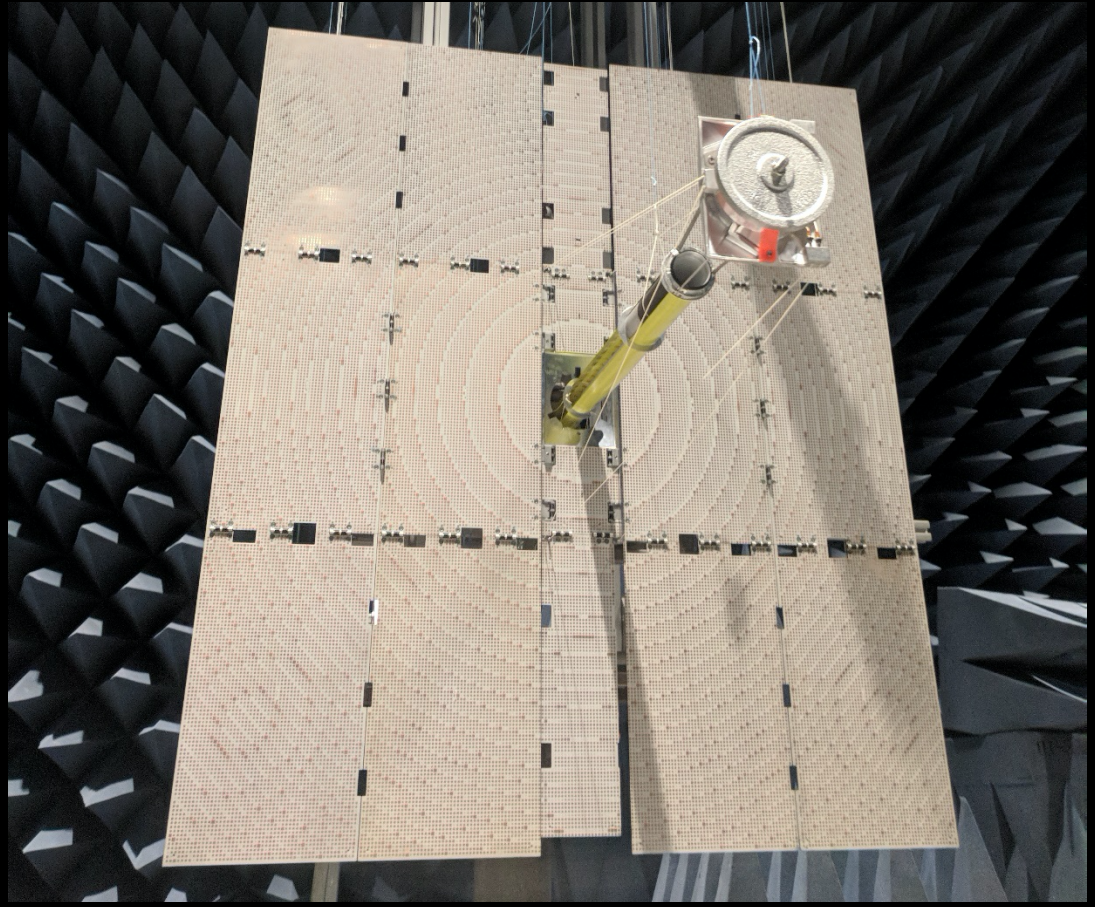

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Special thanks to:

Brian Merrill (Spectrum Marine and Model Services), Michel William, and Tyler Luchik who assisted in building the antenna, and Dr. Jefferson Harrell who performed the RF tests.

Jet Propulsion Laboratory
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